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SENIOR HIGH MATHEMATICS PROGRAM RATIONALE AND PHILOSOPHY

> "The aim of education is to develop the knowledge, the skills and the positive attitudes of individuals, so that they will be self-confident, capable, and committed to setting goals, making informed choices and acting in ways that will improve their own lives and the life of their community".
>
> Secondary Education in Alberta (June 1985)

The high school mathematics program plays an integral part in achieving the primary aim of education. If students are to set goals and to make informed choices as citizens of the future, they will need an array of thinking and problem solving skills. Fundamental to this is an understanding of mathematical processes that can provide an introduction to logical analysis and the methods for making valid inferences.

A knowledge of mathematics will continue to be essential to many other disciplines. However, the nature and use of mathematics is changing, from a discipline that appeared to offer irrefutable conclusions from self-evident principles based on deductive logic, to one that has as its primary purpose finding ways to approach and solve problems using estimation, simulation and other non-rigourous techniques. Moreover, with available information and the use of technology increasing exponentially, the emphasis has shifted from memorizing information such as mathematical formulae and algorithms to finding and using mathematical information to solve problems .

Change in the role of mathematics in society is necessitating a concurrent change in mathematics education, both in terms of content and instructional process. Students must still be exposed to the fundamental concepts but their mathematics education must also include the development and understanding of the ideas that make up those concepts, how they are related and a familiarity with their applications. Most important, students must learn to solve problems using the mathematical processes developed, and be confident in their ability to apply known mathematical skills and concepts to the acquisition of new mathematical knowledge. The current and future technologies must be examined as to their effect on the content component of the curriculum and as to how they can best be used to create more effective and efficient mathematics programs.

The high school mathematics program must be appropriate for students who are at various stages of intellectual development. Most entering students will exhibit mainly concrete operational behaviours in regard to mathematics, and they must be provided with materials and methods of presentation appropriate to their cognitive level. At the same time, they should be exposed to conceptual developments which will help them to progress toward a formal level of cognition.

In order to be successful, the high school mathematics program must involve teachers who are problem solvers, and who are willing and able to model problem solving behaviour for their students. Teachers must be open to new ideas and must demand high standards of effort and achievement from their students. They must possess a thorough knowledge of the mathematics being taught, understand why that mathematics is taught, and be able to select from a variety of instructional strategies for each concept or topic. They must be aware of and able to deal with a wide variety of ability, background and experience.

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Evaluation of the high school mathematics program must reflect the priorities of problem solving and the acquisition of process skills. Students should be prepared to demonstrate an understanding of the concepts presented in a variety of ways, and be able to apply the mathematics learned in the acquisition of new concepts and skills. Evaluation must be more than a mere assessment of lower order skills; process, analysis and problem solving must be appraised with the same emphasis as they are given within the curriculum. Evaluation techniques that go beyond the traditional written test format will have to be considered.

Mathematics education must not be static. It must reflect the changing needs of students and society, and provide the mathematical concepts, skills and attitudes necessary to cope with the challenges of the twenty-first century.

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SENIOR HIGH MATHEMATICS
PROGRAM GOALS AND OBJECTIVES

The overall goal of the senior high mathematics program is to provide students with the opportunity to become mathematically literate. Within this goal are objectives which specify the characteristics of high school mathematics regardless of the stream or course in which a student is enrolled. They are listed as follows:

a) to provide students with success in mathematics by developing streams and courses commensurate with their differing abilities, interests and aspirations;

b) to complete the development of the basic mathematical concepts, skills and attitudes needed to become responsible and contributing members of society;

c) to develop the ability to apply basic mathematical skills and concepts in practical situations;

d) to encourage the acquisition of the skills, concepts and positive attitudes which will allow students to be successful in mathematical situations in future educational endeavours, employment or everyday life;

e) to provide the opportunity for the development of the skills, concepts and positive attitudes which will allow students to continue to acquire mathematical knowledge beyond the conclusion of their secondary education;

f) to develop critical and creative thinking skills as well as skills in analysis, synthesis and conceptualization;

g) to develop the ability to communicate effectively using the language of mathematics correctly;

h) to develop an understanding of how mathematical methods can be used to investigate, interpret and make decisions in human affairs;

i) to provide an understanding of how mathematics contributes to the analysis of natural phenomena;

j) to provide an understanding of and appreciation for the past and future contributions of mathematics as a science and as an art to the progress of civilization and our cultural heritage.

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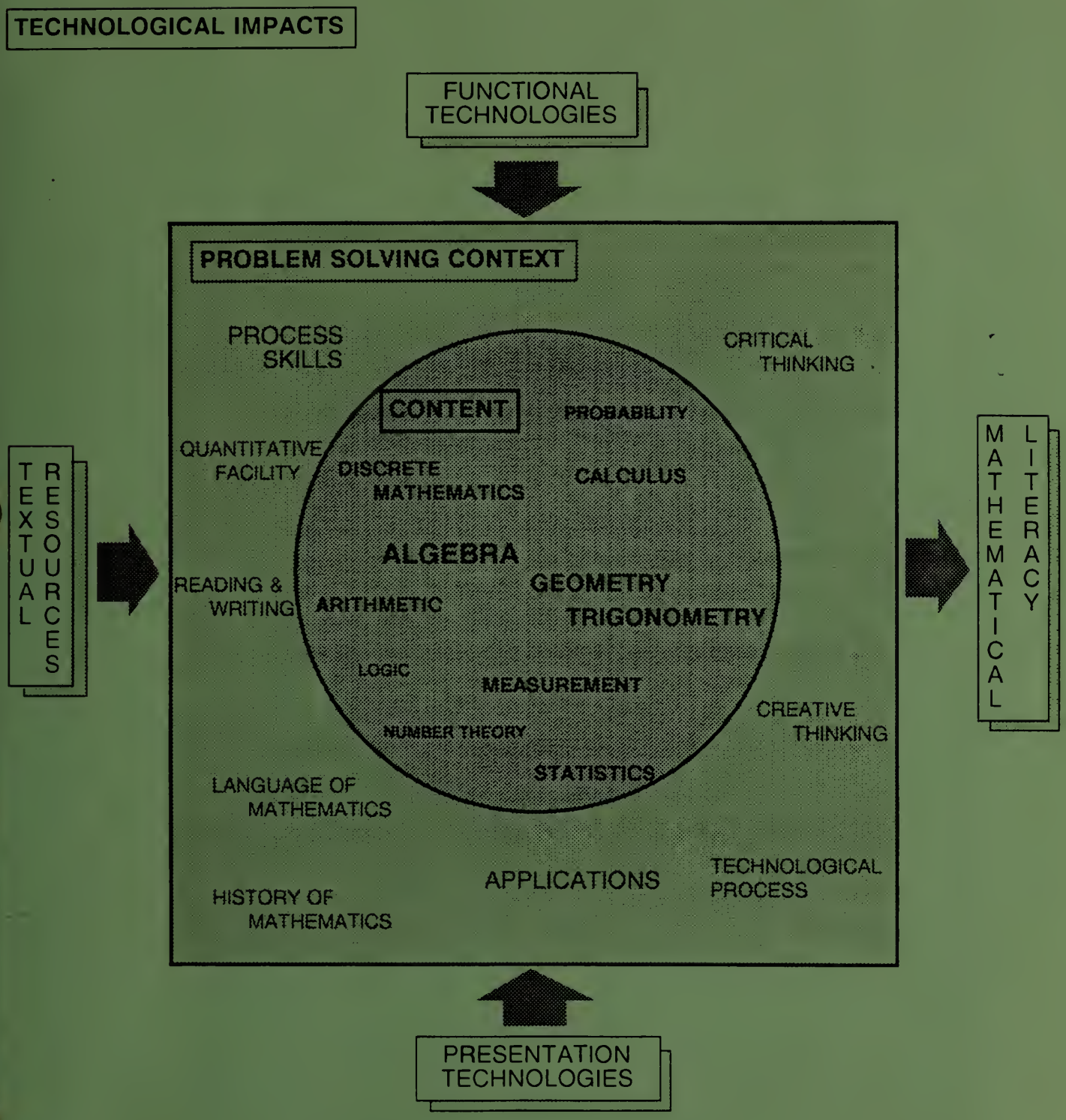
SENIOR HIGH MATHEMATICS CURRICULUM
A MODEL



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SENIOR HIGH MATHEMATICS CURRICULUM
A MODEL

WHAT IS CURRICULUM?

The Secondary Education in Alberta Policy Statement outlines eight principles to guide the development of curricula in the province. In order to incorporate those principles into the high school mathematics curricula, the definition of what curriculum is must be extended. Within the high school mathematics program, everything which is defined as a teacher's responsibility or which is under a teacher's control in the presentation of mathematics to high school students within the parameters of a specified course will be included within the definition of curriculum. This definition will therefore encompass the considerations of content, pedagogy and evaluation.

The model presented here deals with the first two considerations and presents Mathematical Literacy as a general goal to be achieved by students who have completed a high school mathematics program.

The Content of the high school mathematics program is that body of knowledge, skills and concepts which is to be presented to students. In the various high school mathematics courses, it is made up more or less of topics which could be categorized in one or more of the listed strands. Since mathematics is an integrated discipline, most high school mathematics topics cannot be discretely placed in a single strand. The relative importance or emphasis of a strand in the high school program is noted by the emphasis it receives in the diagram.

The Problem Solving Context refers to the instructional lexicon from which the teacher draws during the presentation of the content objectives. The high school mathematics program will focus on problem solving and teachers will use problem solving as the contexture for content presentation. The processes and emphases noted are all possible mediations within which the problem solving context can be developed.

The Technological Impacts are those enhancements to instruction and learning which will be used by teachers and students to augment the quality of the learning situation. Textual Resources are student texts, teacher manuals and other resources. Functional Technologies refers to those which are used as tools by both teachers and students whether as calculation devices or as utilities. Presentation Technologies are those which will be used or prescribed for use by a teacher to present content or provide context for students.

The expected consequence of Mathematical Literacy upon conclusion of a high school mathematics program refers not to a static condition but an attainment of mathematical skills, knowledge and understanding which will provide the skills necessary to deal with the mathematical situations which may be encountered in everyday life or in further educational situations. Mathematical literacy implies an understanding of mathematics and its processes and how they impact on our society, and an ability to communicate mathematical ideas clearly and correctly. Perhaps most importantly, to be mathematically literate means to possess the ability to apply known mathematical skills and concepts in the acquisition of new skills and concepts.

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SENIOR HIGH MATHEMATICS
PROGRAM COMPONENTS

PROGRAM STRUCTURE

In order to address the diverse needs, abilities and interests of students, the senior high mathematics program is comprised of three streams. Each of the streams has the development of mathematical literacy as a primary goal and will present curricular content within a problem solving context.

MATHEMATICS 12-22

This is a sequence of courses designed for those students whose interests and needs in the subject are of a basic nature. Topics will be dealt with using a thematic approach and applications will be a priority. Some topics from junior high mathematics will be covered in Mathematics 12 in order to improve the skill level of students who may wish to transfer to the Mathematics 13-23-33 stream. Students will have fulfilled the mathematics components for qualification for the General High School Diploma upon successful completion of Mathematics 22.

MATHEMATICS 13-23-33

This sequence covers material from the areas of algebra, geometry, trigonometry, statistics and consumer mathematics. It is designed for students who do not require a theoretical approach to mathematics, although it touches on many of the same topics as Mathematics 10-20-30. A student who successfully completes Mathematics 33 should have the necessary background and experience to succeed in Mathematics 30. Students will have fulfilled the mathematics component for qualification for the General High School Diploma upon successful completion of Mathematics 23.

MATHEMATICS 10-20-30

This sequence of courses is designed for students intending to pursue post-secondary studies at a university or in a mathematics-intensive program at a technical school or college. Mathematics 10-20-30 emphasizes the theoretical development of topics from the areas of algebra, geometry, trigonometry and statistics up to a pre-college level. A student who wishes to achieve the Advanced Academic Diploma must successfully complete Mathematics 30.

MATHEMATICS 31

This course is designed for that group of highly motivated, academic students who wish to pursue a first course in calculus, vectors and matrices. Mathematics 30 must be taken as a pre- or a co-requisite course.

COURSE SEQUENCES

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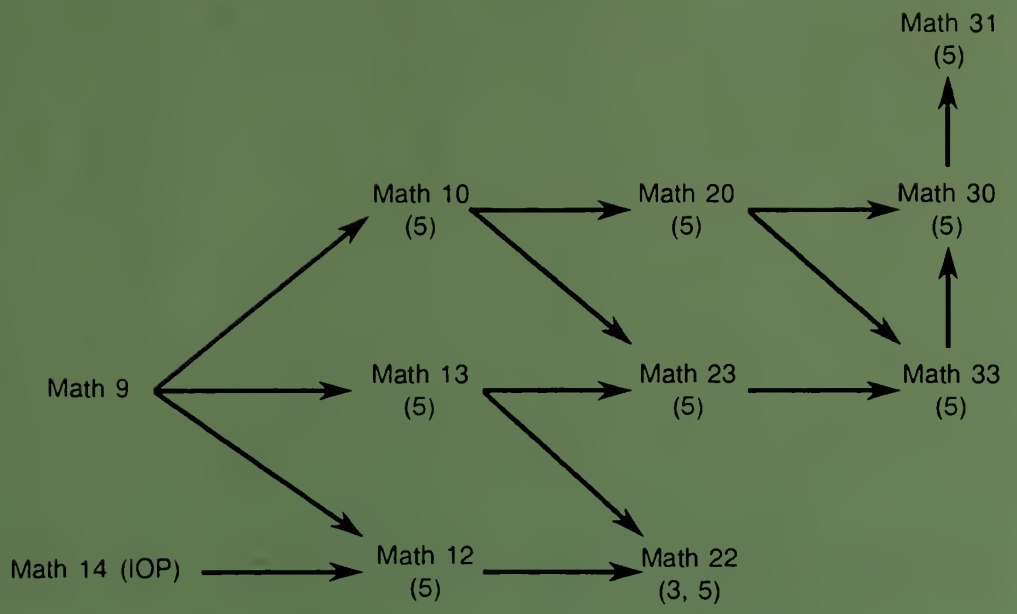

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REQUIRED/ELECTIVE COMPONENTS

The major part of the content of each high school mathematics course is required for all students who take the course. The required content contains the knowledge, skills and attitudes that all students should be expected to acquire. However, each course will have an additional elective component which will be consistent with the content and objectives of its required component. The purpose of the elective component will be to provide enrichment, additional assistance to those students having difficulty with the required materials, or opportunities for innovation and experimentation within individual schools.

In general, for high school mathematics courses, the required/elective split will be 80%/20%. This means that the required portion of each course must be completed within 100 hours.

The elective component is not intended to provide acceleration or advanced placement. However, horizontal enrichment and extension is appropriate and for this reason extended content objectives which seek to offer a more in-depth examination of some topics are included.

PROBLEM SOLVING

Problem solving is the context within which all aspects of the high school mathematics program are to be presented. The emphasis in problem solving has shifted from finding answers to routine "word problems" to applying mathematical concepts, skills and experiences to develop and discover mathematics within a wide variety of problem solving situations.

Problem solving should be the focus of the development as well as the exercise portion of a lesson. Almost all new material can be presented as a problem to be solved using previously acquired skills, concepts and strategies. Teachers must be open to accepting non-rigourous strategies such as

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modeling, working backwards and simulations, and should emphasize the processes used and the type of thinking in which the student is engaged at least as much as the answer to the problem. Teachers should also remember that what may be a problem to some students may be only a routine exercise to others and should be prepared to adapt their presentations to reflect this. Above all, teachers must model problem solving behaviour; students will think problem solving is important if they are encouraged to solve problems by their teachers and if they see their teachers solving problems.

As students become more adept at problem solving, they will begin to use more complex problem solving processes. Such higher level processes will include making and testing conjectures, determining valid inferences, using inductive and deductive processes and developing and using algorithms to apply to a particular situation. At all levels of sophistication, students should be taught (how) to ask good questions and to analyze the thinking processes with which they tackle a problem.

Throughout this scope and sequence, many of the objectives use verbs such as "derive", "discover" or "develop". These objectives suggest explicitly to the teacher that a student should have the background skills and knowledge necessary to successfully achieve the objective using problem solving techniques. Teachers are encouraged to adhere to the spirit of these objectives by treating them as problems to be solved. Students will be more likely to internalize the skills or concepts if they are encouraged to develop them themselves.

For further information on problem solving, please refer to Problem Solving: A Focus for the Future (1987), the monograph produced by Alberta Education for high school mathematics teachers.

CALCULATORS

The integration of calculators into all courses in the high school mathematics program, in class work, homework and evaluation is strongly recommended. By appropriately using calculators, time currently spent practising computation can be freed up to be used on the important aspects of problem solving; formulating questions, devising and evaluating strategies, and verifying and interpreting solutions.

Students must be taught how and when to use a calculator and have achieved proficiency in estimation and mental arithmetic. To use calculators effectively, they must be able to judge the reasonableness of an answer. Making a judgement about the result of a calculation is more important than performing numerous calculations.

Calculators do not serve as a substitute for good teaching, nor do they remove the necessity of understanding basic facts. Teachers must be prepared to teach the appropriate use of the calculator within the development of a concept. It must be looked upon as a tool only, and must not become the object of study. Above all, the use of calculators must not replace the understanding of the meaning of arithmetic operations and the common algorithms used to perform those computations.

STATISTICS

> Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.
>
> H.G. Wells

In a society where advertising is profuse and inferences made by polls about the way we think, act and vote are quoted daily as facts by the media, students must be adequately prepared to comprehend and evaluate the statistics which inundate them. This has necessitated an expansion of the statistics component of all courses, with an introduction to the basics of inferential statistics as the overall goal.

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The content suggested goes far beyond that which is currently in place. As a result, it is proposed that a monograph be produced which will elucidate some of the topics and serve as a teaching resource.

FUNCTIONS

The concept of function is one of the most powerful in all of mathematics. High school mathematics programs have tended to postpone the introduction of functions, and then to introduce the concept only in the highest level academic courses and using the most theoretical and rigourous definitions and examples. As a result, many students have been unable to acquire an understanding of the concept at all and an important part of their mathematics education has been lost.

It is proposed that functions and their characteristics be introduced in grade ten through familiar situations and examples such as problems in which the variables vary directly. By developing the concept within the context of familiar situations, a more thorough understanding of the concept of function will be possible earlier for more students than has been the case in the past.

APPLICATIONS

Unless skills and concepts can be applied in some meaningful way, there is little chance that they will be internalized and remembered over the long term. For this reason, it is essential that students be provided with applications of the mathematics presented to them at the same time as the concept or skill is taught. This is one of the reasons for trying to integrate topics; some topics serve as applications for others. For example, solving quadratic equations by factoring is an application of factoring and perhaps should be presented when factoring of polynomials is taught.

Other applications which are meaningful to students are also available. Some concepts may be immediately applicable to a student's life; others may be seen as having an application at some future time. Another application may simply be something which is interesting or motivational to the student, such as an unusual problem or puzzle. Teachers should be aware of possible applications of the concepts which they present and be prepared to provide them to their students within the presentation of the lesson.

EXTENDED OBJECTIVES

The list of content objectives contains some which are beyond the scope of the required portion of the course. The purpose of these objectives is two-fold. First, they offer the teacher suggestions for extending content within the time provided for the elective component. Second, by using some or all of the objectives provided, it is possible for a teacher to customize the course for a particular group of students who may have special needs or abilities.

ACCURACY, PRECISION AND ROUNDING

In problem solving and in situations which have some transfer to other programs such as science, students should consider the implied accuracy of their answers in comparison with the precision of the numbers used to calculate the answer.

Teachers should be aware of the rules for accuracy. precision and rounding as stated in The Canadian Metric Practice Guide and should work with teachers in other discipline areas so that calculations are dealt with consistently.

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SKILL MAINTENANCE

Most units begin with a skill maintenance objective. Each of the skills to which students have been exposed previously and which will be required in the development of new concepts is listed. It is not intended that the beginning of each new unit necessarily be devoted to review of these topics. Rather it is suggested that they be reviewed as they are needed in the development of new skills and concepts.

TOPIC INTEGRATION

An effort has been made to integrate topics rather than to present them as discrete entities as has been the case in previous curricula. For example, the development and use of the laws of exponents are integrated into the study of the manipulation of polynomials and the solution of quadratic equations is introduced as appropriate within the general topics of number systems and polynomial factoring.

PROGRESS ASSESSMENT AND EVALUATION

Teachers must be prepared to provide both formative and summative evaluations of student achievement. Formative evaluation should be frequent and need not be in the form of a written test or quiz. It should keep students apprised of their strengths and weaknesses in all aspects of the course; understanding of content, acquisition of process skills, problem solving, etc., and should be used by the teacher to monitor a student's day-to-day progress.

Summative evaluations will be used to judge to what extent a student has achieved an understanding of the content of a unit or of a course and to inform students and others of the extent to which the instructional objectives have been achieved. The written test is the most common instrument of summative evaluation, but teachers should be careful that any test used covers all areas of the curriculum, including all of the problem solving aspects and an understanding of the mathematical processes introduced. Some sections, for example some statistics or applied mathematics units, may not be condusive to evaluation by a written test. Consequently, teachers should consider other means of summative evaluation, such as written papers, oral reports or presentations and in-depth interviews.

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